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ASSOCIATION.

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New England Water Works ASSOCIATION.

1890-91.

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NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. V. December, 1890. No. 2.

This Association, as a Body, is not responsible for statements or opinions of any of its members.

QUARTERLY MEETING.

BOSTON, Dec. 10, 1890.

The first of the series of winter meetings of the Association was held at Young's Hotel to-day. The following members were present at the dinner: —

Attendance at Meeting held Dec. 10, 1890.

ACTIVE MEMBERS.

Chas. F. Allen, Hyde Park, Mass.
Solon M. Allis, Malden, Mass.
Chas. H. Baldwin, Boston, Mass.
Joseph E. Beals, Middleboro', Mass.
William R. Billings, Taunton, Mass.
Dexter Brackett, Boston, Mass.
Geo. F. Chase, Taunton, Mass.
H. W. Conant, Gardner, Mass.
R. C. P. Coggeshall, New Bedford, Mass.
Byron I. Cook, Woonsocket, R.I.
F. H. Crandall, Burlington, Vt.
Lucas Cushing, Boston, Mass.
Edwin Darling, Pawtucket, R.I.
Francis W. Dean, Boston, Mass.
Thomas M. Drown, Boston, Mass.
Horace L. Eaton, Somerville, Mass.
Desmond Fitz Gerald, Brookline, Mass.
F. F. Forbes, Brookline, Mass.
Z. R. Forbes, Brookline, Mass.
Frank L. Fuller, Boston, Mass.
Albert S. Glover, Boston, Mass.
W. J. Goldthwait, Marblehead, Mass.
J. A. Gould, Jr., Boston, Mass.
E. H. Gowing, Boston, Mass.
John C. Haskell, Lynn, Mass.
William M. Hawes, Fall River, Mass.

Horace G. Holden, Nashua, N.H.
J. C. How, Jr., Boston, Mass.
Eugene P. Le Baron, Middleboro', Mass.
James T. Murphy, Marlboro', Mass.
Hiram Nevons, Cambridge, Mass.
Albert F. Noyes, West Newton, Mass.
Geo. J. Ries, Weymouth Centre, Mass.
Arthur F. Salmon, Lowell, Mass.
Geo. A. Stacy, Marlboro', Mass.
W. H. Vaughn, Wellesley Hills, Mass.
Chas. K. Walker, Manchester, N.H.
Frank W. Whitlock, Waterbury, Conn.
Horace B. Winship, Norwich, Conn.
Geo. E. Winslow, Waltham, Mass.
E. T. Wiswall, West Newton, Mass.
Millard F. Wright, Lowell, Mass.

HONORARY MEMBERS.

E. R. Jones, Boston, Mass.
Chas. J. Underwood, Jr., New York City.

ASSOCIATE MEMBERS.

Two representatives (H. R. Barker Mfg. Co.), Lowell, Mass.
James M. Betton and friend, Boston, Mass.
A. H. Brodrick (Chadwick Lead Works), Boston, Mass.
Representative (Chapman Valve Mfg. Co.), Indian Orchard, Mass.
F. H. Hayes (Dean Steam Pump Co.), Holyoke, Mass.
Geo. A. Taylor (Gilchrist & Taylor), Boston, Mass.
J. A. Tilden & E. D. Winton (Hersey Mfg. Co.), South Boston, Mass.
Geo. S. Parsons (Holyoke Hydrant & Iron Works), Holyoke, Mass.
Henry F. Jenks, Pawtucket, R.I.
Representative (King & Goddard), Boston, Mass.
F. E. Stevens (Peet Valve Co.), Boston, Mass.
H. L. Bond (Perrin, Seamons, etc.), Boston, Mass.
J. H. Carr (Union Water Meter Co.), Worcester, Mass.
B. Frank Polsey (Walworth Mfg. Co.), Boston, Mass.
E. B. Williams, Boston, Mass.
H. A. Gorham (Geo. Woodman & Co.), Boston, Mass.
Albert A. Blossom (Whittier Machine Co.), Boston, Mass.
Mr. Patterson (H. R. Worthington), New York City.

CANDIDATES FOR MEMBERSHIP.

Geo. W. Harrington, Wakefield, Mass.
W. S. White, Boston, Mass.

GUESTS.

Prof. Wm. H. Niles, Cambridge, Mass.
Senator McDonald, Marlboro', Mass.
Philip Burns, Marlboro', Mass.
George Martin, Weymouth, Mass.
David J. White, Pawtucket, R.I.

After dinner had been served and cigars lighted the President announced that "Our friends who have so often favored us, Messrs. Pratt and Munroe," would sing "Hail Smiling Morn."

The PRESIDENT. — Gentlemen of the New England Water Works Association — not "Boston Water Works Association," as our menus indicate. (Laughter.) I had supposed that our Secretary had recovered by this time. (Laughter.) I have to thank you, gentlemen, for the great honor you have conferred upon me. I regret I could not have been present with you at your meeting in Portland, for I think could I have been there, your choice would have been different. While I feel deeply grateful for your compliment, it has come to me at a time when I could least bear it, so far as the time which I have at my disposal to give to the Association is concerned. Therefore I shall have to ask the earnest support of every member in the matter of making our meetings interesting and successful. I have no doubt I shall have it, and that with such support we may continue to derive benefit from these meetings as we have in years past.

We have come together after our months of work in our individual fields of labor to glean such facts as each has had in his experience which he can impart to the others. It is what we learn in this way that we can make use of in our works in coming years. I presume it will be the desire of the Association to follow in substantially the same line we have pursued in former years in the conduct of these meetings. Several of our members have already volunteered to contribute papers during the winter, but still there is one feature which has been inaugurated with success, and that is the relating of experiences which we have had in little matters. While a thing may seem of little consequence to the member who tells of it, yet it may lead others of us into a line of thought which will be of great value to us on our works. Before the close of the meeting today I shall ask members to volunteer, as so many of them have heretofore, to speak at such times during the coming winter meetings as occasion may allow, and to give us experiences. In the mean time I should like to have the members think this over and be ready to respond. Before presenting Professor Niles I will ask the Secretary to read the names of certain applicants for membership, and we will act upon them now.

The Secretary read the following applications: —

Resident active membership, George W. Harrington, Superintendent, Wakefield, Mass.

Associate membership, Niagara Meter Co., Brooklyn, N. Y.; William S. White, Agent Porter Mfg. Co. (limited), of Syracuse, N. Y., Boston.

On motion of Mr. Fitz Gerald the Secretary was directed to cast the vote of the Association in favor of the admission of the applicants, which he did, and they were declared elected.

Messrs. Pratt and Munroe then sang "The Moon hath Raised her Lamp on High."

The PRESIDENT. — I presume there is scarcely a superintendent or engineer who has charge of any water-supply who is not asked by his commission, or the municipality or board which he represents, what is to be the future of the supply, what can we depend upon, how can we extend it? And I know a large number of our members are engaged in the study of these very matters at the present time. Professor Niles, President of the New England Meteorological Society, has kindly consented to speak to us to-day on "Secular and local variations of weather and climate as affecting water-supply." I have great pleasure in presenting to you Professor Niles. (Applause.)

SECULAR AND LOCAL VARIATIONS OF WEATHER AND CLIMATE AS AFFECTING WATER-SUPPLY.

Professor NILES. — As the demands of modern life are for a great increase in the supply of water and in the facilities for using it, we find more and more necessity for considering the whole range of facts bearing upon the amount available. As all the water we have comes from the clouds, we are sometimes led to ask, Will they continue to fill our extended and multiplied reservoirs? In planning for the future, recognition is taken of the variations of rain-fall, and superintendents and engineers bear in mind the conditions and liabilities of the climates of their respective districts. As the strength of a boiler is determined by its weakest point, so the efficiency of a water-supply may be tested by the dryest season. When a drought occurs, the superintendent may naturally inquire if such periods will probably increase in frequency or become more prolonged. He may ask if the records of rain-fall reveal the probable future. We know that satisfactory records of precipitation do not represent very long periods of time, and accordingly we may reasonably ask if there are any geological evidences of change of climate which may enlighten us upon this subject.

During the summer seasons we may receive a considerable amount of water from what are called local rains or showers, which cover but small areas, and continue sometimes only for a few minutes, but in other instances may be a few hours in duration. Speaking of any restricted district in New England, as, for example, a town or a portion of a county, we may confidently state that during some seasons such showers are plentiful, and other years they are rare.

It is equally true that one of these restricted districts may suffer from several weeks of continuous drought, while another district in New England may have an abundant supply from frequent showers. Another interesting fact is, that some subsequent summer, perhaps the next one, the precipitation in the two districts may be completely reversed. The one that had enough last year may suffer this year, and the one that was parched and brown last August may be moist and green during the same month of the following year. Your speaker has observed striking instances of this in sections that are separated not more than one hundred miles from each other, and has frequently noticed contrasts of the same kind, though perhaps less prolonged, between districts that are immediately adjacent. I am not aware of any regular periodicity in the number of showers, or of any means for making long forecasts of their frequency or ab-

sence, but there is one feature which may be of some practical value, as well as of interest in this connection. It has been observed that if one good shower has watered the land in a tract across our part of the country, another shower seems to be more likely to follow the same track than to make a new one for itself. This, frequently repeated, may give more than sufficient to one belt of land, and leave a parallel tract in want until some general storm traverses a broader area.

We are thus led to ask if there are any known reasons why showers should frequent the paths traversed by the preceding ones of the season, and seem to avoid other tracks. Starting with the well-known fact that the moisture of the clouds has been supplied by evaporation, we proceed to notice that a shower can continue its copious precipitation only by being fed. The surfaces which have been well moistened by previous rains supply, by evaporation, the material the progressing showers need for their subsistence. The dry surfaces, on the contrary, furnish only unfavorable conditions, and frequently the showers which arrive at their borders are there dispersed from the want of material for their continuance. It is then that the farmers see abundant signs, but receive no rain; and then it seems true that "all signs fail in dry weather." Good things are not equally distributed, and the rains do not fall wholly upon the just or the unjust, but only upon uncertain portions of them. The wet regions become wetter, and the dry regions become dryer. The situation of two water-board superintendents, the one in the shower belt and the other not, may be represented by a familiar Scriptural passage, particularly if a change of three words be allowable: "For he that hath, to him shall be given; and he that hath not, from him" evaporation taketh "even that which he hath."

I think we may now draw the following conclusions: When in summer-time the showers pass our district without entering it, we may wisely economize our supply, even though others in New England are receiving a plenty. When a large city finds a necessity for obtaining its supply from more than one hydrographic basin, there may be an advantage in it, particularly if they are not adjacent; for, as has been noticed in the flow of streams, one basin may be favored by local rains when the other is not.

It was remarked that the geological evidences of the desiccation of climate, which are so evident in the western portion of the United States, likewise show that there have been times of increase as well as of diminution in the supply. Even if it could be asserted that our own climate is becoming dryer, it would not follow that the change would continue in the same direction. Let us not infer that because a number of years have been wet or have been dry that a permanent change of climate is being established, but rather that a period of one extreme is likely to be succeeded by one of opposite character.

The local distribution of rain and snow in the Pacific Highlands of the United States and its connection with the great problems of irrigation were discussed, and it was predicted that the future demands upon the profession of hydraulic engineering will greatly exceed those of the present day.

The PRESIDENT. — When our worthy ex-President, Mr. Nevons, very kindly consented to help out in providing for this meeting, in speaking of Professor Niles and what he would say to us, he said to me: "Noyes, he is brimful, overflowing, bubbling over with information; there isn't anything you can bring up but what

he can tell you about." Well, I have been thinking that the Professor is a good deal like our friend Nevons's fountain on Fresh Pond. (Applause.) You have seen it when they let the water on from Stony Brook, how it bubbles up and flows over, and just so the Professor seems to be brimful of information. We have with us one of our members who has given a good deal of thought and study to this question, and I know you will all be pleased to hear from Mr. Fitz Gerald. (Applause.)

Mr. Fitz Gerald. — Mr. President, I am very glad you didn't tell me I was to be called upon, for, after all, I think it adds a great deal to the enjoyment of a dinner if you feel you haven't got to make a speech after it; and that is the condition I have been in during this very interesting entertainment thus far. During the last summer I had rather an interesting visit in Washington, and had the pleasure of meeting with Major Powell, who, as you know, has charge of almost everything in the West, I was going to say, except the railroads; he has charge of all the irrigation schemes, the geological surveys and the topographical surveys. I spent a couple of days with him, and afterwards he turned me over to some of his assistants. I was astonished at the organization and the executive ability that has been displayed, and at the tremendous schemes which are under way. I do not know that all of you are aware of them, and perhaps I will say a few words on that subject, as that has been introduced to some extent by Professor Niles.

Major Powell, of course, does not pretend to be a hydraulic engineer, and he has had the very good sense to put his different departments under the charge of experts. I found that he had divided his whole work in the West into three grand departments. There is the topographical department, through which he has had surveys made of almost all of the favorable sites for reservoirs for irrigation purposes; and, in fact, you may say that almost the whole country west of the Mississippi river is being contoured. Then he has courses of geological surveys going on. He has also made up a very large party of engineers all over the country, who are at work under what he calls his hydrographic division, and these men are measuring the flow of the streams in a very systematic and a very excellent way. Then he has still further a construction party, who are engaged in getting up the plans. Well, to an engineer who is working around in one little place, — and most of us are, — it seems like working on a pretty big scale when you cover the whole country. But his plan is certainly a very long-sighted one, very far-reaching; and I anticipate when his reports come out, as he has been working on the matter for a good many years, we shall have a great deal of exceedingly interesting matter presented. I believe that Congress has practically stopped the operation of the homestead act, the pre-emption act, so that no lands can be entered by settlers, and practically the whole matter has been put into Major Powell's hands; and until he sees that he has got all the best sites for the reservoirs, and for the canals, and for his irrigation schemes, no land can be entered upon. He hopes very soon, realizing the responsibility of this, to be able to put things back in their old position, after having selected these sites.

I have just come back, arriving only last night, from Chicago and Cincinnati, and perhaps you would like to hear a little description of some reservoirs I saw at Covington. It makes an Eastern man, after all, pretty well satisfied with the water here, when he sees the kind of water they are obliged to drink there. I

remember — what year was it, Brackett? (Laughter.) Well, never mind. Some years ago, when I first went West, I stopped at Cincinnati on my way out. I had been accustomed to drinking water in my youth (laughter), and I told the waiter when he brought me a glass of something (laughter), that I didn't call for lemonade. "Why," said he, "Lor', Massa, dat ain't lemonade, dat is watah." (Laughter.) It was a long time before I could bring myself to believe it was water, still it tasted very good. They have entirely different problems there from ours. Almost all their water is filled with sediment, — river water. At Covington they pump the water from the Ohio, up about three hundred and fifty feet, into two reservoirs. They selected a valley which had two little spurs, and these particular reservoirs are built in the valley between the spurs, and are connected with another reservoir at the bottom. The water is pumped into these upper reservoirs alternately, so it has an opportunity to settle in one, and is then carried into the lower one while the other is being cleaned out. I was glad to see these reservoirs. One of them is going to be filled next week, so I had an opportunity to go into it and examine the construction pretty carefully. And I was very much pleased to see the paving. The paving is laid in cement, on a preparation of broken stone; and very nicely laid, very fine class of paving. The slopes are three to one. Those of us who have had any experience with the slipping of paving laid under these conditions will realize the necessity of such flat slopes. The bottom of the reservoir is laid with an inclination of one foot in one hundred, and they have connections all around it with holes, so they can slush the whole thing down to the outlet. And the lower prism of the reservoir is arranged to catch the sediment. On the inlet pipe is a very nice arrangement with a float, so they can draw from different depths without having very many gates in their gate-house. And as the sediment collects on the bottom, they have another pipe; the same pipe continues into the bottom with a large plug, and when there is a good deal of sediment on the bottom they run a little truck down from the gate-house with a crane, and lift this plug, and slush all the mud out into the creek.

There are a good many of these interesting things in the West. Of course the more we see of the different kinds of construction, the more we are led to see the breadth of water-works construction and of engineering practice. And I think we must all have been struck with the thought during Professor Niles's very interesting remarks, that what takes place in one part of the country does not in another, so that there is plenty of scope and room for study and investigation. I am sorry I have not something more interesting to say. (Applause.)

The PRESIDENT. — I don't know what Mr. Fitz Gerald's aspirations may be, but I certainly think I voice the sentiment of all the members in saying that we have found his remarks very interesting. Coming into the hall to-day, I couldn't but notice one of our members, who has generally been very sturdy, showing a certain weakness which led me to feel there must have been a scarcity of water somewhere. Perhaps Mr. Hawes can explain. (Laughter and applause.)

Mr. HAWES. — Gentlemen, I will acknowledge being a little weak in the knees. (Laughter.) I had the misfortune to fall down and hurt my knee-cap about five weeks ago, since which time I have been limping, and this is the first day I have been without a crutch since then. But I was not drunk at the time, although I have had time enough to get drunk since, if there had been any need

of it. (Laughter.) But I notice when you get into an emergency you always call on Fall River. (Applause.) Well, we are always ready to help out. We have got about 80,000 inhabitants there, and we have considerable many we can spare just as well as not. (Laughter.) If you have a war we will send you down four regiments in less than twenty-four hours. If Boston has a big fire we will send you six steamers very quick to help you out. And if you are up a stump, we will send you two Traffords, who will save Cambridge and Harvard University and the credit of Massachusetts at football (laughter), and thus preserve the good old name of John Harvard. (Laughter.) We have got plenty more left of the same kind; we can send you down any quantity. So I suppose your President thinks now that in order to help things out he must call on Fall River.

I was very much pleased with the remarks of Professor Niles, our able expounder of practical theology. (Laughter.) He certainly has expounded one point which a good many of us have stumbled over in reading the Scriptures. He has also solved that arithmetical problem, "naught from naught leaves naught," "nothing from nothing leaves nothing." He has shown us that he who hath *not*, that shall be taken from him; and it can be done. (Laughter.) I am glad I came here to-day, glad to meet you all, and glad to have listened to the interesting remarks of Professor Niles. I never thought so much about this subject of providing water for the future. You know the Scripture says, "Take no thought for the morrow what ye shall eat or what ye shall drink or wherewithal ye shall be clothed;" but most of us have taken thought, or a great many of us have, for the morrow as to what we shall drink. A good many have been puzzled about it; but I don't think we need to fear very much. Only a short time ago I saw a little squib in one of the papers that the Newport Ice Co. were now producing ice — and by the way, all their capital is in Fall River — by artificial means, and next season they expect to be able to produce it from water from the ocean. I don't know by what process, but they propose by evaporation to take the salt from the water, and then to freeze it and give it to us more pure than spring water or any water that comes from the earth. I don't see why we need go on worrying about the water of the future. Here we have got the whole Atlantic Ocean behind us, and all we have got to do is to extract the salt, freeze the water, then shove it into our reservoirs and let it melt, and we will supply the whole world with ice water. (Laughter.) Now, gentlemen, go home and rest easy; the problem is solved. (Laughter.)

In conclusion, I would like to move that the thanks of the New England Water Works Association be extended to Professor Niles for the interesting address which he has given us here to-day, and I will take the liberty to put that motion myself. (Laughter.) All gentlemen in favor of this motion say Aye so they can be heard. (Shouts of "Aye," and laughter.) Those contrary-minded will leave the room. (Laughter.) It is a unanimous vote.

The PRESIDENT. — I presume, like all commissioners, Mr. Hawes would leave the financial part of his scheme of furnishing the world with ice-water to the superintendent.

Mr. HAWES. — They are producing ice now cheaper than natural ice, and when they get the water from the ocean it can be done for nothing, probably. (Laughter.)

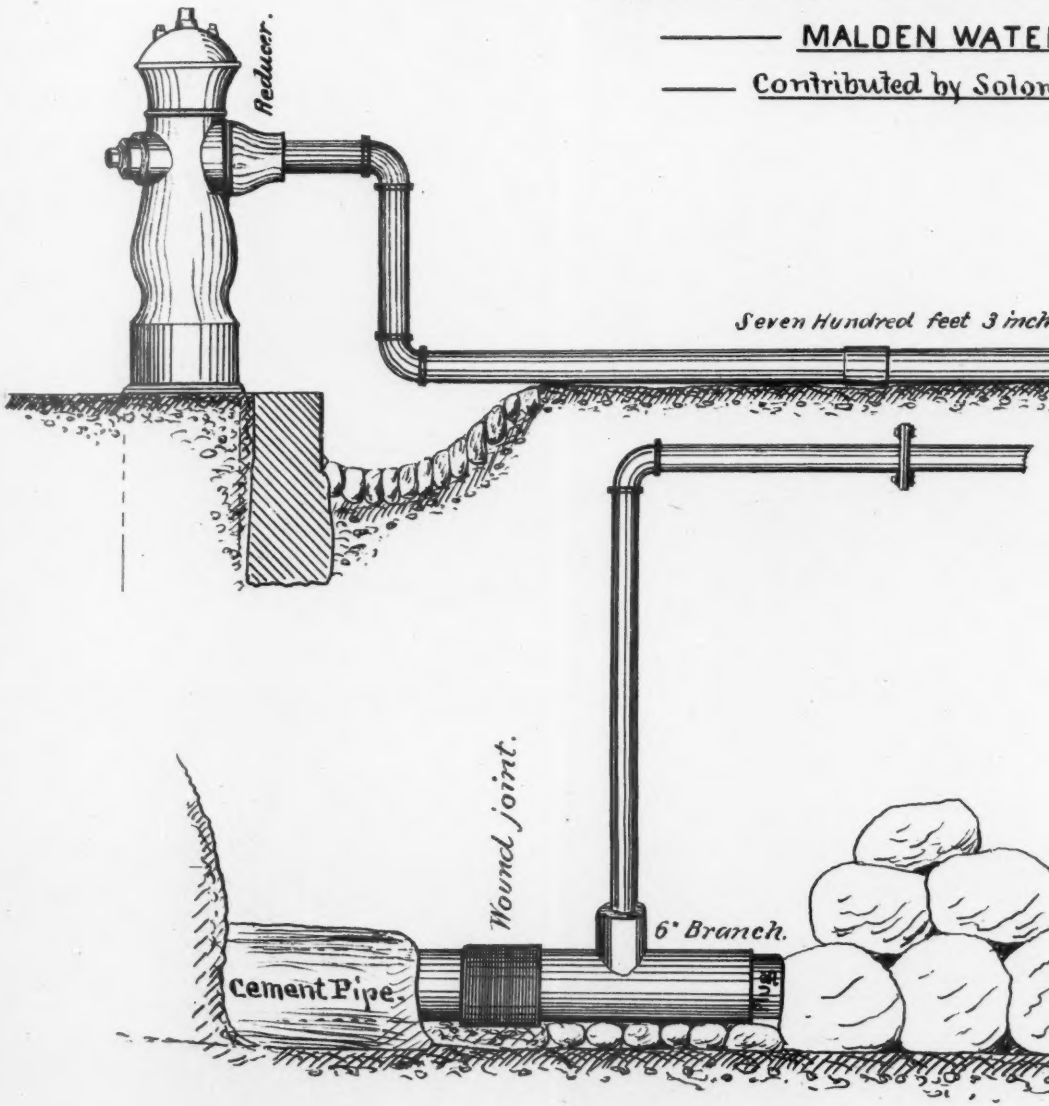
SKETCH SHOWING SUP

OF WATER

Supply not cut off while rel

MALDEN WATE

Contributed by Solon



SURFACE CONNECTION———

ER PIPES.———

relaying using old ditch.———

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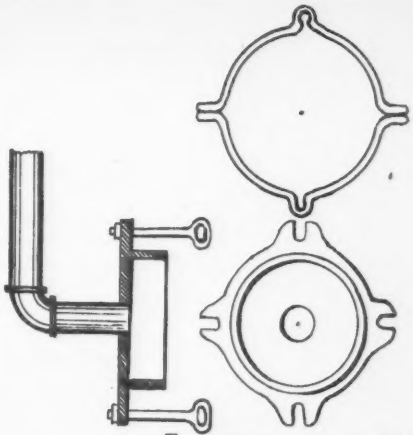
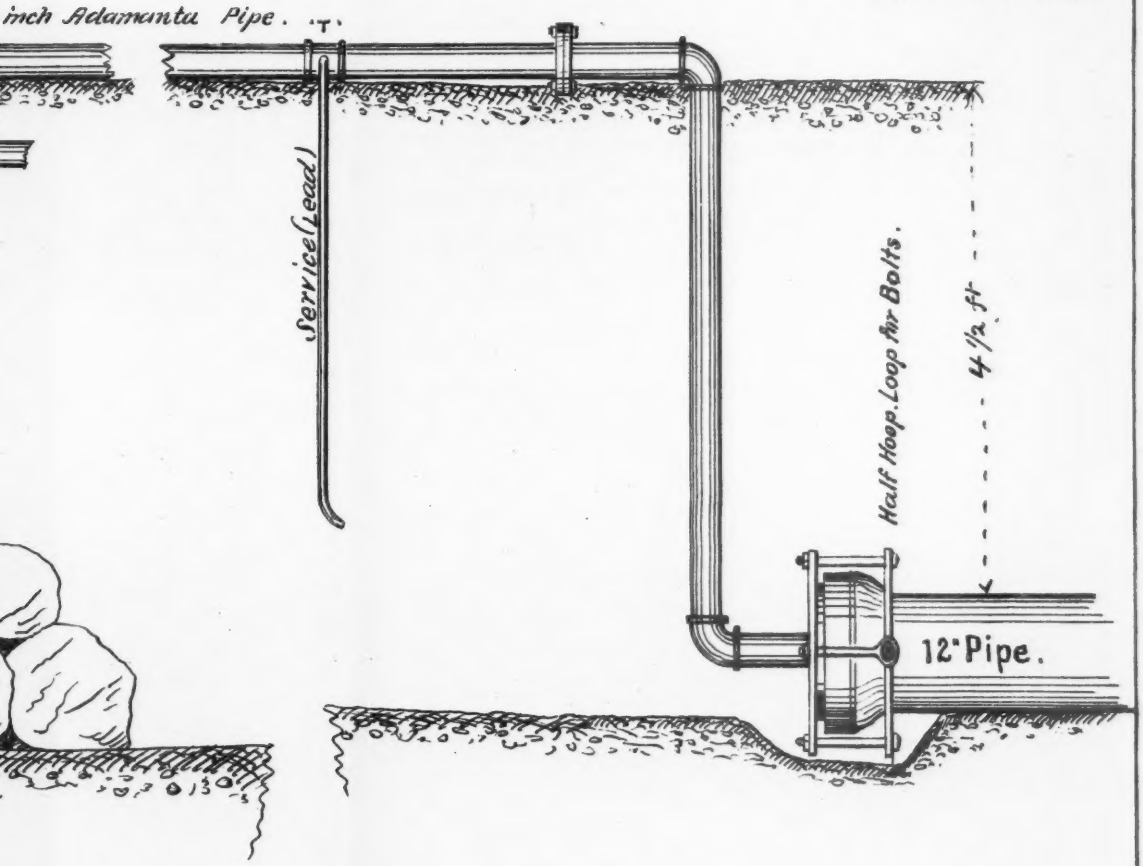
olon M. Allis. Supt.———



PUDDLE PLUG 12"



The PRESIDENT. — We have with us this afternoon Mr. Allis, superintendent of the Malden Water Works, who will present to us the results of some experience which he has had this last year.

Mr. ALLIS. — I suppose all the members of this Association have more or less of relaying of street mains to do, especially those who have a legacy on their works in the shape of a lot of cement-lined pipe that has outlived its usefulness.

We have found in Malden that it is necessary from year to year to relay those mains first in use, now about twenty years of age.

This year we relaid about eight thousand feet on one of our principal streets, replacing six-inch cement-lined pipe with ten and twelve inch cast-iron. Heretofore we have followed the usual custom when relaying to dig a new ditch on the opposite side of the street, so that if any blasting was done it would not break the weak pipe before we were ready to abandon it.

On the street mentioned we have nearly one thousand feet of hard ledge, as the street is built against a steep, rocky cliff, and it occurred to me that if we could take out the old pipe and use the old ditch we would find it comparatively easy digging, and save somewhere about two thousand dollars. The last twenty-eight hundred feet to be laid was the only pipe that supplied the village of Linden, containing about (700) seven hundred inhabitants.

To take out this pipe and replace it with twelve-inch cast-iron, and not suspend the supply, was the problem that we had to deal with.

I first connected three-inch adamanta pipe to a hydrant on the old pipe, using a reducer made to fit the steamer nozzle, as shown in the blue-prints, and, crossing the street, laying the pipe under the street-car rails and just beneath the surface in the roadway, put on a quarter-bend. Then from here I laid, say, five hundred feet of the same along the sidewalk or in the gutter until I reached a convenient place. Here I crossed the street again and cut out the old pipe and connected with the further end by a common tee-branch and wound-joint, first driving a wooden plug into one end of the branch and piling up a few large stones to hold it firmly in place.

Where services were required I had placed three-inch tees tapped for corporations as near opposite the stopcocks as possible, and each one was temporarily connected with a short piece of lead pipe, after the water was let on. I then took out the old pipe (previously stripped), cleaned out the ditch, lowered it where necessary, proceeded to lay the new pipe between the points connected as above described. While this was going on I had the new pipe tapped for services and ready for the corporations, and as fast as a piece of the work was completed for the day, connected at place of beginning. Then at the end of the newly laid pipe I bolted a cast-iron puddle plug, attached the services and proceeded to fill the trench, first moving my three-inch pipe along and connecting with the puddle plug, restored the circulations temporarily suspended. As I had about seventy pounds pressure at the pump, the pipe used, although small, answered the purpose, and no complaint was made of want of water for domestic purposes; but as it would have been quite inadequate if a fire had broken out, I was very glad when the job was completed with no mishap of that kind.

I do not know as this method of relaying pipe is new, but never having seen it in use myself, I thought it might be; and perhaps this description may be use-

ful as a hint to such of our friends who have plenty of ledges in their way, and we all know that kind of work means expense which we would avoid, if possible.

The PRESIDENT. — I will call on Mr. Whitlock, city engineer of Waterbury, Conn., a member of the Connecticut Engineers' Society, and one of our members whom we do not see at every meeting.

Mr. WHITLOCK. — Mr. President and gentlemen of the Association, I have been very much in the same condition that Mr. Fitz Gerald was in before he was called upon; that is, I have been enjoying myself without any expectation of saying anything. I hardly know what I can tell you with reference to our works or our method of management which will be particularly interesting. Perhaps, however, I can give you a short outline description of the arrangement of the works. Our works are entirely a gravity system. We have in operation now four reservoirs. The first of these is at a distance of about two miles and a half from the city. The supply, although at first laid with 12-inch, is now 18 and 16. The original system was laid in cement pipe, — cement and iron; the present is nearly all of it cast-iron. Above the distributing reservoir, which is about three-quarters of an acre in area, is our main reservoir. This has an area of about 100 acres, and is at an elevation of about 175 feet above the distributing reservoir, the connections being through the open channel of the brook on which these two reservoirs are built, and also by percolation through the hills on the north side of the reservoir near which the dam is situated. Above this main distributing reservoir is still another one on a separate brook. That is connected with a line of 12-inch pipe about three-quarters of a mile long. That is about 40 feet above the main reservoir.

Then just outside of the city limits on the north side of the city — these I have mentioned are on the south-east side of the city outside of the city limits — just outside of the city on the north side we have what was put in for a compensating reservoir to take the place of a stand-pipe. This has served its purpose very well in its way, and has, aside from its purpose in taking the place of a stand-pipe, a small supply of its own. We are now in the position of so many other towns in New England, in search of a water-supply. Our town has increased within the last twenty years, I think, somewhere in the neighborhood of from 100 to 110 per cent., and the consequence is the supply which was originally designed for a town of from fifteen to twenty thousand inhabitants is insufficient. I think of nothing more I can tell you. (Applause.)

The PRESIDENT. — We have with us to-day one of the veterans in water-works management, and I will call upon our honored brother, Mr. Jones, ex-superintendent of the Boston Water Works.

Mr. JONES. — Mr. President and gentlemen, I merely want to relate a little incident by which I once got a great deal of information, — information that I expected when I retired from the works I might turn to some advantage; but two years have gone by and I haven't been able to realize anything from it, so I will give it to you; it won't take but a few minutes. I related it to one of our members one evening, and he says, "Why don't you tell it to the Association?" So I will. It is a way of catching fish, — fish inside of the pipes, — which some water works are troubled with, ours especially, I know, and one year more seriously than in other years. We had a leak on one of the streets at a dead end of

the pipe. It was dug down to, the pipe taken out and taken to the yard as usual, and we found it split from end to end. I looked into it as I sometimes do, — or did when I was on earth (laughter), — and I found in that pipe some fifteen or eighteen perch with their tails stuck into the crack. (Laughter.)

Well, when I came to think the matter over I saw how it happened. This pipe was on the end, — it was the very end of that line of pipe, — and the whole pipe beyond the last customer, the winter being very cold, had frozen up and nobody knew it, because the last customer had got water all right. Of course when it froze up it burst the pipe the whole length of it. When it thawed out in the spring it showed the leak, and of course it was such a large leak that it drew the water from the whole territory, — it was over in East Boston, — and with it drew the fish, or perhaps they went there because there was such a commotion they wanted to see what it was; and when they got frightened and turned tail it was too late, and the pressure of the water drew their tails into the crack. Then when we shut off the water from the pipe the crack closed up and the fish were there. That is my method of catching fish that I wanted to relate to you. (Laughter.)

The PRESIDENT. — At the opening of the meeting I suggested that one of the features of our meetings in the past had been the relation of experiences by the members, and I wish now to call upon the members to volunteer to relate during the winter some of the interesting little things they have encountered in their work the past year. I shall have to ask Mr. Walker and Mr. Gowan not to go out, for we are going to call upon them. (Laughter.) Seeing them upon their feet, however, I have no doubt they are the first two volunteers, and I shall therefore take the liberty to put them on the list. (Laughter.) And now I wait for other members of the Association to volunteer.

Prof. DROWN. — I have no experience to give, nor any information, but I can tell the members where they can get some very interesting information on the subject of purification of water-supplies. To-morrow evening at the Society of Arts, which holds its meetings in the Institute of Technology, the main building, there will be a paper read by Mr. Devonshire, an English engineer, on the method of purifying water by metallic iron. Mr. Devonshire is the agent in this country for the Anderson process. He has experimental works at present in Philadelphia, and will explain to water-works people and others interested in this question in this region what the Anderson process is. Perhaps I may say one or two words, not anticipating what he will have to say upon the subject, but merely explaining what it is, as the expression seems somewhat contradictory, — purifying water by metallic iron. Perhaps it may be known to many of you that the distinguished chemist Virchow some years ago made the spongy iron filters. These can be had now-a-days on a small scale for household use. When they were experimented with at Antwerp on a large scale they were found not to be practical, because the filter became clogged. Mr. Anderson took the idea up and tried to put the iron into the water, and take it out again in a somewhat different way from what Virchow did, namely, to put the iron into a revolving cylinder and pass the water through it. A certain amount of metallic iron is in this way dissolved. The revolving of the cylinder is for the purpose of keeping the particles of iron bright, if they are wrought-iron, and if they are cast-iron little pieces will be chipped off. At all events, a little iron is

dissolved in this way and goes into the water. The water is then exposed to the air, or air is forced through it if required, and the iron which goes into solution is precipitated by the mere fact of its becoming oxidized, and allowed to settle for a season. Then the reasonably clear water is filtered by the ordinary form of filtration as carried on abroad on the continent, that is, by continuous filtration through sand. These works are now going into Antwerp and some other places in Holland; I don't think there are any in England. This system has been experimented with by the celebrated engineer of the Berlin Water Works, and he has reported favorably upon it, and Mr. Devonshire is now in this country to introduce it here. I thought it might interest members of the Association who are interested in this subject to know that they could have an opportunity to hear him to-morrow evening at eight o'clock at the Society of Arts, at the Institute of Technology. (Applause.)

The PRESIDENT. — I thank Professor Drown for his invitation, and I have no doubt many of us will avail ourselves of it. Now, I will renew my request for volunteers. (Pausing.) I do not hear any responses, but it is undoubtedly owing to the modesty of the members of the Association, and I therefore shall assume the authority given to the President by the constitution, one of the fundamental points of which is that every member is bound to obey the wishes of the President, and shall proceed to name as volunteers (laughter): Mr. Darling, Superintendent of Water Works, Pawtucket; Mr. Gowan and Mr. Walker, who rose some time ago; Mr. Nevons, Mr. Brackett, Mr. Fitz Gerald, Mr. Beals, Mr. Forbes, Mr. Chase, Mr. Eaton, Mr. Haskell, Mr. Ries, Mr. Stacey, Mr. Jones, Mr. Winslow, Mr. Fuller, Mr. Cushing, and Mr. Gould. Now, these have all volunteered (laughter), and because others have not been named, I do not wish it to be understood that they are not desired to volunteer, and we shall expect that they will respond under the requirements of the constitution. It has been intimated that Mr. Hawes has one or two more remarks to make. (Laughter and applause.)

Mr. HAWES. — When I hear the President say that, I want to say that I am something of a liar myself. (Laughter.) I don't believe anything of the kind has been intimated to him. Our new President seems to have a very fertile brain, and he has shown it by conjuring up all these volunteers. (Laughter.) I don't believe half the men he has designated can give any experiences as to water worth listening to, and I therefore hope that they will be permitted to relate some of their other experiences, which may be more interesting. (Laughter.) I really had nothing more to say, and I have said it. (Laughter.)

On motion of the Secretary, the meeting adjourned to Wednesday, Jan. 14, 1891.

[*From Journal of Association of Engineering Societies.*]

WATER-SUPPLY AND ITS DEVELOPMENT FOR SMALL CITIES IN THE WEST.

BY

WYNKOOP KIERSTED.

[Read before the Engineers' Club of Kansas City, Nov. 7, 1890.]

The object of the present paper is to consider in a popular way the development of public water-supplies; particularly with reference to the many progressive towns in this portion of the West.

So many towns have failed to realize their anticipations in securing a public water-supply, that the town authorities seem either to have been ill-advised or to have misapprehended actual conditions; some cases of failure are directly due to inappropriate methods of development.

An experience gained by one or several successive failures is expensive and undesirable. Small towns can ill afford to pay for information on such matters two or three times its market value. It is much better to preclude failure by a thorough and systematic investigation.

No matter what the size of the town may be, this question of water-supply so involves the health, happiness, and protection of the community, that it demands the best and most disinterested consideration of town authorities.

Small communities, relying on cisterns and wells, often cling to them when the growth of the town should encourage better protection. Cisterns are usually for the storage of rain-water, and many suppose that from this source comes the purest and best supply for domestic uses. This view is all very proper when it refers only to the use of water for ordinary kitchen purposes; but if it includes its use as a potable water, it is an erroneous one, for the reason that noxious and soluble gases and fine dust emanating from animal and vegetable life, from the decay of organic substances, from the disintegration of mineral matter, and from fuel combustion, are as native to the air as sediment is to a flowing river, and the rain as it descends absorbs these atmospheric impurities, surrounds them with conditions favorable to chemical action, and reaches the earth in a state of greater or less impurity.

Even this source of pollution need not render rain-water in the vicinity of small towns unfit for a general domestic use were it kept from other contaminations; but, on the contrary, by contact with painted and dirty roofs and gutters on the way to the cistern, and the great liability of these receptacles to the percolation of surface water, additional sources of pollution are encountered.

Within the cisterns the conditions are unfavorable for the circulation of air and water, and any gases arising from the enclosures are readily absorbed. Thus it is that rain-water by the time it is used can become exceedingly impure.

Open wells draw towards them the ground-water from considerable distances in all directions, and, when in the vicinity of cesspools and privy-vaults, become a receptacle for their sub-surface drainings. It is commonly thought that water by percolating through the ground will become pure. This idea, however, must have its limitations, since water to be purified by natural filtration must pass

through porous and well-drained soils permitting of a free circulation of air and the process of oxidation; but when draining through or from deposit vaults into the deep sub-soils, it is simply filtered, and may enter a neighboring well perfectly clear, but most dangerously foul with matter in solution.

Even drive-wells, with an iron-encasing tube, are not exempt from such dangers of pollution; because there being no storage capacity to a drive-well as to open wells, a depletion of the soil extends in all directions immediately upon draft, and this depletion is more extended the greater and more continuous the operating power attached to the well, so that it is only necessary for the drainage from vaults in the vicinity to reach this affected district in order to find access to the well.

Cisterns and wells are, of course, a necessity in the early history of a community, but they demand constant vigilance as the price of freedom from contamination; and in estimating the quality of the water from either source, it is never safe to depend on appearances, for though the water from them may be clear and sparkling, it is not, for all this, necessarily pure; even sewage may be clear as crystal.

Both methods of water-supply can well be discarded for everything but the ordinary house uses, as soon as the town can afford to procure water from some safe and reliable source.

The waters of drainage and percolation, collected naturally in rivers, lakes, and in porous sub-soils, are the immediate source of large local supplies, and may be divided into surface and sub-surface supplies, and even these facilities are more or less limited according to the locality.

Of the surface supplies, the best comes from some one of the great rivers. These waters, by flowing over and through uneven beds of silicious sand and gravel of considerable slope, and by being brought continually in contact with the air, are freed from organic matter by oxidation. The retained impurities are chiefly sediment in suspension, which are readily disposed of by settlement in basins or by filtration. What hardness there may be in such waters is usually not sufficient to interfere with general domestic service. The intake from such a source should be located in a main channel, and at a point above the town, where pollution from sewage and manufacturing waste cannot reach.

Lakes in this central western district, if they exist at all, are usually unfit for furnishing good water, and can scarcely be considered here.

Circumstances sometimes favor impounding reservoirs, which store surface waters collected from a more or less extensive water-shed. Such supplies are desirable where the impounded water can possess depth at the expense of superficial area, and can be free from contact with vegetable soils and polluted surface drainage. When the drainage valleys are broad, the stream burdened with sediment, the vegetable soils deep, and the sub-soils porous, the conditions are very unfavorable for the construction of dams and the storage and maintenance of pure water.

Many inland towns are so situated that surface water either cannot be obtained at all, or it is at an expense beyond their present means; consequently, resort must be had to sub-surface supplies; and these may be both from deep and from shallow sources.

The deep sources furnish water by means of artesian wells from the ancient geological formations, consequently it is liable to the impregnations of mineral matter.

The shallow supplies, often in considerable quantities, come from the drift formations of sand, marl, and gravel from 50 to 150 feet in depth, and are usually good for all house purposes.

In locating a water-supply of this kind, caution is to be observed, for absolute reliance on a yield from such a source is extremely hazardous unless preceded by a thorough and skilled investigation.

In the first place, the laws governing ground-water flow are to be strictly observed, and are practically the same as those governing the flow of surface waters. The movement of the water through the ground, however, is very slow, due to the great resistance of the soil; and this resistance varies with its degree of fineness, — for instance, water will pass very freely through a mass of bowlders or coarse gravel, more slowly through sand, the rate of flow decreasing as the material becomes more finely divided, clay permitting very little to pass.

Much also depends on the extent of the water-bearing material; whether it is an extensive reservoir, holding water collected from many square miles of watershed, or is simply a pocket supplied in the immediate locality, to become exhausted by a short season of pumping or during a drought.

It is evident from the character of such rivers as the Platte, Republican, Kansas, and Arkansas, that the porous soils under and on either side of them must be in a continual state of saturation, and constantly transmitting the waters collected from rains on inland districts; otherwise, the water in the river basins would entirely disappear by downward filtration. The fluctuations of the rivers depend largely upon the degree of this saturation, and upon the extent of these storage reservoirs.

Generally in these broad valleys almost inexhaustible supplies of water can be obtained, in degrees of purity depending upon the amount of vegetable, animal, and mineral matter that is encountered in the soils. The same is true of the tributary streams and valleys, except that their supplies come from more limited water-sheds, percolate nearer the ground surface, and are, consequently, more affected by drought.

Inland towns can often be supplied from the same subterranean reservoirs as the river towns, but in this case the depth of penetration is usually greater, with a proportionate increase in attendant risk and expense.

It may seem that these few statements of the general distribution of a ground-water supply are opposed to the necessities of the tests heretofore referred to, but this is only apparent; for, while a knowledge of the geology of the country, of the meaning of surface appearances, and of the existence generally of large subterranean reservoirs, is essential and suffices for predictions, it is not positive information. There is always a lack of homogeneity in the deep subsoils, faults in the geological structure, natural upheavals, and other disturbances, which, like bowlders in a surface stream, so prevent an uninterrupted flow that tests in any locality are essential to establish conclusions. When so much depends on investigation and actual test before the location of a water-supply and the means of developing it can be settled, it is difficult to tell why it is that communities will often be satisfied with a sort of a "witch-hazel" location, and

accept almost any device for securing the water, without a proper consideration of its adaptation to existing conditions. It is to be regretted that such cases are not few, and always involve a fruitless expenditure of public funds.

The common practice of locating a water-supply on the public square, or on some vacant lots within the corporate limits of the town, is a most precarious proceeding. Usually it is for no other reason than to reduce the first cost of the works, or because the man who makes the investigation does not receive remuneration enough to pay him for the trouble of investigating a water-supply outside the town limits. While considerations of economy are good and are particularly necessary with small communities, they lose all force and argument when opposed to the health and comfort of the public. This water must surely be drawn from under the town, and most certainly will be polluted by the drainage from privy-vaults and cesspools. This danger has undoubtedly received little thought from the authorities accepting such a location, and no doubt many will scout the idea; but from the very fact that it is a danger, a positive danger, unseen and unfelt until it appears as an epidemic among the people, renders the duty to avoid it an imperative one.

As a matter of fact, a public water-supply is usually from the deeper water-bearing strata, which are often separated from each other by layers of clay, or a mixture of clay and sand, but frequently of sufficient thickness to prevent intercommunication. A circulation of water which may have been impracticable or impossible before the construction of a system of wells, is, by their existence, in many instances made not only possible, but probable; for the reason that in piercing the various strata a channel is opened for the passage of the upper water to the inlet of the wells.

A continuous draught drains the surrounding ground for many hundred feet, producing conditions favorable to a downward percolation of water, so that any drainage from underground receptacles of filth, by the slow process of filtration, is liable to reach the affected district, and ultimately to find access to the homes of the community.

As a rule, the best location for a water-supply is in the main drainage valley, or in one tributary to it above the town-site, for there the danger from underground pollution is diminished and the expense of interception the least. Objections are often raised to such a location near a stream, because the water in a river, by an occasional foulness, may be liable to taint any supply in its vicinity. Such objections, though plausible, may frequently be rejected; because experience in various instances has shown that filter-galleries, even though located close to a river and below the low-water line, receive the greater part of their water from the land side.

Though the water in a filter-gallery or system of wells fluctuates with a rise in an adjoining body of water, this does not prove an inland flow, but as nearer the fact of the case, that this rise dams the approaching water in the soil, causing it to rise therein to accommodate itself to the new conditions, — as, for example, the water in wells sunk in the sand closely bordering the ocean has been found to fluctuate with the tide while maintaining its freshness; also in a very cold climate the ranges of the temperature in the water collected in an uncovered gallery was noticed to be very small compared with that in a river bordering the gallery. No doubt there is always some inland filtration at times

of a sudden rise in a stream, the extent depending on the condition of the soil at the time; but the danger of fouling a well-located water-supply in the neighborhood is very slight.

As has been said, the only way of finally determining a water-supply after the site has been selected is by actual tests, and such tests must be manipulated in a very careful manner, or the results obtained will be overestimated.

A good way to make these is as follows: Sink an open well, three to five inches in diameter, into the water-bearing strata; remove the earth within the tube by means of a jet of water forced through a small pipe, one inch to two inches in diameter, by a steam-pump. By this means the character of the soils passed through can be observed. At various distances from this well, and in at least two directions, drive small pipes one and one-half to two inches in diameter in line to the same depth as the first well, and so as to permit free access of the water at the bottom. A small pipe for a pump connection can be inserted inside the large well and a pump attached. For this purpose a steam-pump is preferable, or one that will permit of a continuous pumping for any length of time, practically fulfilling the requirements of actual service.

The fluctuation in all the wells should be carefully noted at stated intervals and at various speeds of operation; the amount of water furnished can be measured by any convenient and reliable means. Whenever pumping ceases, the time required for the water to assume its original elevation in the wells, and the rate of change in this transition, is to be carefully observed.

It will be noticed that it takes the water in the ground considerable time to accommodate itself to any change of conditions, so that for certain results long periods of pumping are necessary, and for this reason the work should not be hurried.

Frequently, several water-bearing strata will be encountered, separated by layers of clay, the upper ones being generally supplied from local water-sheds, and the soonest affected by draught and drought, while the deeper ones may collect water from a very large collectible area, and give a large and uninterrmittent yield. It is best to penetrate these deep and more extensive reservoirs to insure success.

That such tests are the notable exception throughout this country is true, and with the present haste to develop a scheme as soon as decided upon, the disinclination to spend money on preliminary investigations is very strong.

When properly made, they require a reasonable expenditure of money. The methods suggested, however, are not those to be put into practice by the novice or ordinary well-digger. The required plant can be found in any town, but the man under whose supervision the work is to be done should be a specialist, whose study and experience makes him familiar with all questions of water-supply, the laws of flow, the usual conditions of ground-water storage; and one who is trained to minute observation and analytical methods of reasoning.

When a general public sentiment favors a water-supply, the time for action is at hand; not, however, in a way to make a public issue of the question for the time, for such decisive action is not propitious.

The usual custom of appointing a commission or committee to investigate the matter is a very good one; and their trip around the country to inspect various water works gives them a knowledge of the subject which will be of great assistance to them in their future duties. It is serviceable thus far, but no farther. It is surely a mistake to let such an investigation conclude to them that a system of water-supply or water works in any neighboring town is exactly what is wanted in their own town, and so recommend to the people or common council; for, as yet, there is nothing to show its adaptation to local circumstances and conditions.

The best way for such a committee is, in the very beginning of their work, to select a competent engineer to study the question with them; to determine by necessary tests the best locality for a water-supply, its quality and amount, and the best means of developing it. Let him submit a report, with an estimate of cost of the entire water works, best adapted to the needs and means of the community. This puts the matter in a tangible form to present to the public for discussion and vote. They know then just what they are doing, and how far they can carry their undertaking.

Such a preliminary investigation is not putting the people to any extra expense, for it will have to be made before any reliable and complete set of plans is prepared, and the proper time to make it is before any popular vote is taken on the issue of bonds for the work, or any franchise granted to a constructing company.

In most cases where a franchise is granted the people cannot be too particular from where their water-supply is coming, and how it is to be preserved from contamination. Such an investigation and report as the one suggested is a community's safeguard; and if municipal authorities would take such a rational view of the case, they would often save themselves vexations, delays, and embarrassing failures. If some method of this kind is not adopted, but the works projected and constructed in an unsystematic way, it is simply a question of a few years before the expert will be called to perform the very work that should have initiated the enterprise; and it may be at greater expense to the city, for remodelling of a plan is by no means economical or satisfactory.

Committees who have located their water-supply in the corporate limits of the town, where the soil is for years liable to defilement, whether the town be sewered or not, have particularly this question to consider in a twofold way. First. Ground in a town is expensive, and they usually have made little or no provision for the future extension of their works. Second. The location is so opposed to any proper sanitary regulations, that it is only a matter of a little time before a healthy public sentiment will fully appreciate this circumstance, and compel a relocation away from all possible chance of such foul pollution.

The method of development, as well as the location of a water-supply, is a fundamental consideration, and is to be studied as an isolated problem, as far as the most feasible adaptation of a means to an end is concerned. It is bad policy to assume, as is sometimes done, that every means of developing a water-supply is worthy of a general application, even over a limited territory, because it has been successful in any one or two places. This is simply "putting the cart before the horse." The condition and peculiar requirements of the

town and surroundings must first be determined; then apply that method most suited to the location.

In this section of country, where the supply comes from a river or a reservoir, connection is usually made directly with pumping machinery. Sometimes auxiliary filters are constructed in the banks; but experience has shown that these very often become useless by clogging with silt, and that they need constant attention. Artificial filters are now constructed by several companies, and great pains are being taken to make them successful as an attachment to a water-works system.

Sediment is very readily disposed of by settling in basins properly capacitated to the size of the water-works system.

When ground water is the source of supply, resort is usually had to infiltration galleries, large open wells, systems of drive-wells arranged in gangs, and bored wells, sometimes the last of large size, each well fitted with an independent steam-pump.

Infiltration galleries are usually constructed in the porous material near a river. Such galleries should be kept covered, for the collected water, being in reality filtered, is liable to pollution if exposed to the light and heat of the sun.

Open wells are one of a variety of infiltration galleries covering a small area of ground, but penetrating deeper to reach a suitable water-bearing strata; in relation to them it has been determined that the bottom area alone can be depended on to furnish water.

Thorough tests should precede the sinking of such wells, so that the various materials to be encountered, and their depth, are definitely known and the most satisfactory point of stopping the excavation thereby determined.

Serious mistakes have frequently been made by unintentionally uncovering deep beds of quicksand or clay, which a little knowledge in advance would have prevented.

Perhaps the best example of drive-wells arranged in gangs is the system used in Brooklyn, N. Y. Here the wells are in pairs on each side of a main suction-pipe.

In distributing drive-wells along a pipe, or in any manner to draw water from the ground, it is necessary first to know the maximum demands on the system, the rate at which the soil is capable of furnishing water, and the depth of the water-bearing strata. No well should, during its maximum draught, approach the limiting capacity of the soil to furnish water, nor should the draught be so severe as to permit the hydraulic grade-line to fall below the top of the entrance to the pipe, as this will constantly impair its action.

As an example of what an improper distribution of wells will do, a case may be cited where a failure occurred, due to the incapacity of the soil to furnish water. In this case the wells, about thirty or thirty-five in number, were arranged in a circle twelve feet in diameter, all having entrance to a tight (?) drum. Under a slow rate of pumping they operated very well, but before the draught reached the specified requirement, one million gallons per twenty-four hours, the supply failed.

There was water enough in the sub-soils, as had been determined by experiment, but the fineness of the material prevented a flow rapid enough to supply the demand from so limited an area of pipe distribution. One-third to one-half

of the drive-wells were inoperative. Had the same number been properly distributed the result would certainly have been very different.

Various methods of distributing the wells are pursued, but unless good judgment is shown in the adaptation of the method to the conditions and in their mechanical adjustment, they fail to give the best results.

Bored wells 5″ to 8″ in diameter are sometimes used, when the water-bearing material is at a considerable depth, each well being supplied with an independent steam-pump. Such plants, being low service, require a storage reservoir of considerable capacity at the pumping-station, additional high-pressure pumping machinery for the distribution system, and large boiler capacity. The operating expenses are necessarily heavy, due to so many independent pumps and the large amount of fuel consumed in the manufacture of steam. Each of these methods of developing a water-supply has its adaptation, but none can be recommended for any general use. In fact, it is not difficult to conceive of conditions, liable to be encountered, where each may, in turn, have superior merits, although instances where the last method can be economically and advantageously applied to water works are exceptional. Sometimes a combination of two or more methods produces good results.

A choice of method, whether mentioned here or not, depends upon so many things, chiefly upon the requirements of the locality, as developed by test, that few suggestions can be given. It is best to rest the matter with a competent specialist, who is familiar with all these things, and let him arrange and design the plant. Such a disinterestedness is necessary in the adviser, that he can investigate the matter for the public good and not be biased by personal interests in patented devices and so-called systems of water works.

By looking over official records and the results of health commission investigations the proof will be found ample to justify the most vigorous protests against the use of water from wells or in the immediate vicinity of any town. It is a historical fact that the health of cities and towns is largely controlled by the source and character of their water-supply, and thousands of cases of cholera and similar diseases are directly traceable to a water-supply contaminated by cesspool drainage and fæcal matter. It is not necessary to cite the many proofs of this statement. One has only to read to find enough to convince the most sceptical. It was once stated by the Mayor of New York, namely, "When cholera last visited our city every case could be traced to the use of well-water, where not a single case occurred where Croton water was used." In the terrible scourge in the small town of Plymouth, Pa., in 1883, the death of every individual could be directly and most conclusively traced to a contaminated water-supply emanating from a single patient of typhoid fever.

[*From Journal of Association of Engineering Societies.*]

THE FILTRATION OF NATURAL WATERS.

BY

THOMAS M. DROWN, Member Boston Society Civil Engineers.

[Read January 15, 1890.]

In the study of the subject of filtration of water for drinking purposes, we shall arrive at no clear and valuable ideas unless we distinguish sharply between mechanical filtration, which deals only with the interception and retention in the filter of the solid particles suspended in the water, and filtration combined with the oxidation of organic matter, — that in solution, as well as that in suspension in the water. This latter process — the purification of the water by the oxidation of its organic contents — can be accomplished only by *intermittent* filtration, the former — the mere removal of the solid particles in the water — may be accompanied by *continuous* filtration, as practised in many large cities in Europe.

When we speak of the purification of water by filtration, we mean, in a general way, that a water is thereby rendered fit to drink which was unfit or unattractive before it was filtered. The change effected by filtration may be simply the removal of vegetable or earthy matters, whereby the water is made more palatable and more attractive in appearance, or it may be more radical in converting water which was positively harmful into a good drinking-water. Widely different in action as are the two systems of filtration, the intermittent and the continuous, yet it is possible by both systems to improve the quality of a bad water.

In the system of continuous filtration, in which there is little or no change made in the dissolved organic matter, it might at first thought seem as if there could be only imperfect purification; but it must be borne in mind that it is possible in this system to remove in great part even those very minute organisms, the bacteria.

The germ theory of disease furnishes us with the simplest explanation of the way in which water does harm, and if we can, by simple mechanical filtration, remove the harmful germs from the water, we have effected a true and efficient purification of that water, whatever may be its chemical composition. Let us push this idea a little farther. If we take as the basis of our theory of harmfulness of water that disease is caused by it only when micro-organisms are present in it, then if we could by the continuous filtration of sewage remove absolutely all the germs which it contained, leaving unchanged its other characters, — appearance, taste, odor, etc., — this sewage would be perfectly safe to drink. To put the matter in another form, a sterilized water or sewage has no possibilities of producing disease except so far as it may contain saline or other substances which may produce derangements of the system in the same way as would a drug — a dose of salts or of senna. It is foreign to my present purpose to consider whether our knowledge at present justifies this position, but it is important to bear it in mind in judging of the efficiency of filtration.

When water is said to be well, or moderately well, or completely purified by filtration, we cannot know what is meant unless we know what is the standard of purity implied. Is it simply the removal of color, odor, and suspended matter? is it chemical purity, meaning thereby the absence of unoxidized organic matter? or is it bacterial purity or freedom from germs? Again, what shall we say of water of high chemical purity, with high bacterial contents; or what of a water with few or no bacteria which contains considerable organic matter capable of undergoing change?

Intermittent filtration is capable of giving water free from organic matter and free from germs; continuous filtration, if conducted very slowly, is capable of giving water free from bacteria, without odor and color, but which may contain much dissolved organic matter. Intermittent filtration effects the oxidation of the organic matter in solution as well as that in suspension; continuous filtration has little or no effect on the organic matter in solution.

After laying such stress on the removal from water of bacteria, it sounds like a paradox to say that purification both by intermittent and continuous filtration depends on the presence in the filter of bacteria in enormous number, and that without them the purification would in both cases be impossible.

The idea is not a new one that the bacteria of decomposition are benign and useful organisms which break up organic matter, rearrange its atoms and convert it into mineral matter so that it may again serve as food for plants. If we keep away the bacteria from a mass of dead organic matter it undergoes no change whatever. All processes of decay of organic matter are absolutely dependent on the presence of these micro-organisms, which, so far as we know, have no other than a beneficent rôle to play in nature. I say this is now a matter of common knowledge, and one is therefore not unprepared to hear that in the purification of water by intermittent filtration the ground or sand upon which the water is poured is full of bacteria; in fact, that it is the design of the process to cultivate them and have as many of the micro-organisms in a cubic inch of ground as possible.

If one pours over a column of clean, bright sand, free from bacteria, impure water, as sewage, it will flow out about as bad as it entered the sand. But if it is poured over a column of sand in which septic bacteria have been cultivated, so that the sand may be said to be fairly reeking with bacteria by the million, the water may flow out as pure (organically) as spring water. But even in continuous filtration, where there is little or no oxidation going on the bacteria are, according to Piefke (the engineer of the Berlin Water Works), the efficient agents in removing the suspended matters, including the micro-organisms in the water. To this subject we will return later; let us first briefly study the nature of oxidizing or intermittent filtration on the typical polluted water, namely, sewage.

Sewage is a substance which contains all of its nitrogen in the unoxidized form. Its principal ingredient is free ammonia; it also contains considerable (but a much less amount usually) organic nitrogen, or albuminoid ammonia, but of nitrous or nitric acid it contains none. When sewage is exposed to the air in mass, oxidation goes on very slowly, because it can only get air from its surface; when it flows out into streams, the oxygen dissolved in the water of the streams quickly oxidizes the ammonia, and we find in the water a short distance below the entrance of the sewage nitrites and nitrates abundantly. When the

sewage is exposed to the air in very thin layers, as when a porous material like sand is moistened with it, oxidation goes on with great rapidity. It was until recently considered that this oxidation was a direct chemical combination of the elements of the organic matter with the oxygen of the air, or the oxygen dissolved in the water; but we now know that nitrogen is not oxidized by the direct contact of decomposing nitrogenous matters with air, unless bacteria are present, and the inference, seems a fair one, that the greater the number of bacteria the more rapid the process of oxidation. Sewage itself usually contains hundreds of thousands of bacteria to the cubic centimeter which are dormant until air gets access to it. If sewage is preserved out of contact of air, the bacteria of decomposition will in time all die.

The experiments of the Massachusetts State Board of Health on the purification of sewage by intermittent filtration which have been carried on at Lawrence for the past two years, under the direction of Mr. Hiram F. Mills, the engineer member of the Board, have added largely to our knowledge of the conditions governing the purification of nitrogenous organic matter. Here are large tanks, $\frac{1}{200}$ of an acre in surface, filled with different materials — coarse sand, fine sand, river silt, muck, garden soil, clay, etc. — to the depth of five feet, on which is poured from day to day sewage in known amount and of known composition. The effluent water from this sewage filtration is collected, measured, and analyzed and the precise amount of purification determined. The result of two years' work at this station will shortly be published in the report of the Board now in press. I will at present give one or two of the facts that have been there developed. The purification of the sewage means the complete oxidation of all its organic ingredients both in solution and in suspension, — the carbon to carbonic acid, the hydrogen to water, and the nitrogen to nitric acid. The filtering materials best adapted to the purpose are those which are fine enough to retain considerable sewage in their pores and also plenty of air at the same time.

The body of porous material is, when in good working order, a very delicate machine. It must be coaxed up to its highest efficiency by gradually increasing the amount of sewage. This means, in all probability, that we must develop in the pores of the sand an immense number of bacteria to be constantly on hand in the different layers to attend to the sewage as it reaches them. During the first winter there was no nitrification in these tanks, and consequently no perfect purification; but on the advent of spring, when the temperature of the effluent water reached 39° F., nitrification began, and has continued ever since, the cold weather of the second winter failing to stop it.

The tank which has given the best results, that is, a good purification of the largest quantity of sewage for a long period, is filled with coarse mortar sand, most of the grains of which average about 0.06 inch in diameter. This has given an effluent day after day organically as pure as many drinking-waters, when receiving sewage at the rate of nearly 60,000 gallons per acre per day.

One would naturally ask, Why is not this the ideal system of purification of all surface waters, even those that are not polluted by drainage of any kind, but which contain much vegetable suspended matter, and have, in consequence, sometimes a bad odor; or waters which are unattractive in appearance by reason of dissolved coloring matter?

One of the tanks of the Lawrence Experiment Station has filtered Merrimack water intermittently for more than two years at the rate of 300,000 gallons per acre per day. The filtering material consists of 3′ 8″ of coarse and fine sand and fine gravel, 10″ of yellow sandy loam, and 6″ of brown soil in the same position as found on the river-bank. During the day the surface of the sand is generally covered with a few inches of water, but at night and on Sunday air gets access to the sand. The following figures give the composition of the filtered water during last December, compared with the Merrimack water applied: —

	Parts per 100,000. MERRIMACK RIVER WATER.	Parts per 100,000. FILTERED WATER.
Turbidity	very slight.	none.
Sediment	very slight.	none.
Color	0.35	0.0
Odor	faintly vegetable.	none.
Total solids	4.2	3.5
Loss on ignition	1.6	0.9
Free ammonia	.0015	.0005
Albuminoid ammonia	.0127	.0059
Chlorine	.18	.18
Nitrogen as nitrates	.0124	.0191
Nitrogen as nitrites	none.	none.

The water is free from microscopic organisms, and the bacteria rarely exceed 10 or 20 per cubic centimeter, while the water applied has generally a few hundred. During the two years that this tank has been in operation the surface has *not been cleaned or disturbed in any way.* The slow rate of filtration (being only about one-half an inch an hour per square foot of surface) is due to the considerable amount of very fine material contained in the soil and loam.

But one must bear in mind, in connection with the rate of filtration, that the thoroughness of the purification, meaning thereby the oxidation of the organic matter, is much greater in intermittent than in continuous filtration.

This system of intermittent filtration for natural waters has never, I believe, been carried out on the large scale, although the possibility of its being practicable in some localities has been discussed. It is the system that nature suggests, for it is intermittent filtration which supplies the springs which furnish the ideally pure and perfect drinking-water. In the report of the Massachusetts State Board of Health to the Springfield Water Board with regard to the purification of the water of its Ludlow reservoir, which contains an immense growth of blue-green algæ, Mr. Stearns, the chief engineer of the Board, suggested that surveys be made to discover, if possible, suitable ground, conveniently situated, on which to pour intermittently the water of the reservoir and to collect it again at lower levels in wells and springs. It is probable that continuous filtration would be inapplicable to water of this kind, for the jelly-like masses which are secreted by these algæ would probably close the pores of the filter in a very short time. With intermittent filtration the deposit of organic matter in the pores of the sand would dry out or become oxidized when the ground was more or less dry.

It has been to many a difficult matter to explain how filters working continuously, and constantly covered with water, could intercept objects so much smaller than the spaces between the particles of sand. It was easy to imagine that some of the minute, suspended particles might be caught between the particles of sand, but that practically all the suspended matter, even the minute bacteria, could be removed in a good-working filter, seemed to indicate that the efficient working of a filter depended on the fact that it became nearly clogged on the surface by the algæ and other matter which held back even the smallest objects. But if this were the case it would save time to use a finer sand at the outset, which experiment shows will not accomplish the purpose.

Piefke has given us the clearest conception of the action of sand filters in removing the suspended matters, including bacteria, from surface waters. The chemical effect is very slight, as might be supposed when one reflects that the duration of the passage of the water through the sand seldom, if ever, exceeds five and one-half hours; and, since the filter is kept constantly covered, there is no oxygen present but that dissolved in the water. But the mechanical effect in removing suspended matter — mineral and organic — is very great. The Spree water, which forms part of the supply of Berlin, contains as high as 100,000 bacteria per cubic centimeter at times, and the number in the filtered water rarely exceeds 100, that is, the reduction of bacteria may reach 99.9 per cent. The thickness of the sand layer is generally from 2′ to 3′, and this rests on a layer of coarser gravel, which is without any effect on the filtration. The size of the sand is seldom finer than one-fiftieth of an inch, which leaves channels between the grains that 500 micro-organisms could pass abreast. Smaller still are the particles of clay which give a milkiness to water, and yet when one of these sand filters is working well both clay and bacteria are held back in the sand.

It takes a new filter about two weeks to get to its maximum efficiency, and if the sand be first carefully cleaned and sterilized by heat, then it takes much longer — many weeks — before the filter works well.

On examining with the microscope the surfaces of the particles of sand when the filter is in perfect working order, they are found to be coated with a greasy, slimy substance which is a mass of bacteria jelly. Piefke found in a kilogram of sand taken from the surface of a filter 5,600,000,000 bacteria, just below the surface 734,000,000, and at the depth of a foot 92,000,000. These numbers, he says, are far below the truth, because of the difficulty of cleaning the particles of sand thoroughly. It is to this coating of bacteria jelly that Piefke attributes the efficiency of these filters, and until the jelly forms in sufficient amount to completely envelop each particle of sand, the filters work imperfectly. This, then, is his explanation of the fact that minute micro-organisms and particles of clay of infinitely smaller size than the channels in the sand are stopped in their passage through it — they are simply caught in this slimy coating and cannot get farther.

A filter of this kind is, like that used in intermittent filtration, a very delicate instrument, and it is very easy to disarrange it. Disturbance of the sand or suddenly increasing the pressure of the water may have, as a consequence, a rush of bacteria into the filtered water. Quite regular working is an essential condition of success. The rate of filtration is on an average only four inches

vertically an hour, so that in the passage of the water through the sand, one-third of which is interstitial space, its rate is three times as great, or twelve inches an hour, and the sand layer being two feet thick, the water is in contact with the sand only two hours. In very turbid waters or waters very high in bacteria the filtration is often decreased to one-half this rate or even less, and in comparatively clear water, with low bacteria, the rate may be doubled. The working of the filters in Berlin is governed entirely by the number of the bacteria in the filtered water, this being the simplest way of judging of the efficiency of their working. One hundred bacteria per cubic centimeter in the filtered water is considered a good result on the Spree water, which contains always many thousands. To give practically sterile water would require a diminished rate, say to one vertical inch an hour, which would be impracticable without enlarging the filtering plant.

The surface waters used to supply London from the Thames or the Lee are filtered by the method of continuous filtration, a surface of one hundred acres being required for the purpose. The thickness of sand differs with the different companies supplying the city with water, from two feet at the East London and Grand Junction Companies to four and a half feet at the Chelsea Company, and the rate of filtration per hour in imperial gallons per square foot of filtering surface is two and one-sixth with the Lambeth Company to one and one-half gallons with the Southwark & Vauxhall Co. To one and one-half gallons, or five vertical inches, an hour (which is seldom attained) is considered the maximum consistent with good clarification. Complete analyses are made of the water supplied to the metropolis by the different companies. Some of the determinations, as, for instance, color, and the amount of permanganate to oxidize the organic matter, are made daily; other chemical determinations are made weekly. The monthly determinations made by Dr. Percy F. Frankland of the bacteria in the waters of the different companies have been suspended since December, 1888. The average reduction of the number of micro-organisms present in the waters of the Thames and Lee was in 1887, 97.6 per cent. in the case of the Thames, and 93.9 in the case of the Lee. "If," says the report on the metropolitan supply for December, 1888, "these figures could be accepted as at all representing the degree of security given to consumers of the waters of those rivers by preliminary filtration, it is evident that the views on this subject acquired by a consideration merely of the results of comparative chemical analysis of filtered and unfiltered waters would have to be considerably modified, and the character of the water-supply would be correspondingly raised in public estimation. Further, if the results obtained from month to month could be relied on as an index to the effect of filtration in eliminating objectionable matters from the water, the bacteriological method would seem to afford a delicate and easily applied test of the working efficiency of the filter."

The average number of bacteria in the water of the Thames is generally less than in the Spree at Berlin; thus, during the year ending December, 1887, the highest number, in November, was 81,000, and the lowest, in June, was 2,200, the average for the year being 21,492.

The only filtering plant in this country that I know of which at all compares with the plants in Europe is that at Poughkeepsie, where the Hudson-river water is converted into good, clear water, though not absolutely free from color. Mr.

Fowler, the superintendent of the works, writes me with regard to the details of the filtration: "Our usual rate of filtration is about six inches per hour, vertically, and this we regard as the maximum of efficiency, although we can sometimes do good work, so far as clarifying is concerned, at double that rate, and at other times are unable to do good work at one-half that rate, although the latter condition is exceptional. Very much depends upon the condition of the water in the river. The depth of water on the sand varies from one to three or four feet, and the difference of level between the surface of the water on the beds and that in the intermediate basins is usually two to four or five feet."

The rapid filtration of water through coarse gravel is not infrequently carried out at water works to remove the larger particles floating in the water. When a filter of this kind is cleaned it is surprising to see the amount of fine dirt of all kinds that has been intercepted by the coarse material. Filters of this character do not pretend to purify the water in the sense of removing bacteria or in oxidizing the organic matter, but they are useful just to the extent to which they clarify the water, and thereby improve its appearance.

The American system of filtering large quantities of water may be said to be the mechanical filters working under pressure. These filters are composed of four or five feet of moderately fine sand (some have also a mixture of coke) enclosed generally in boiler-iron cases. They work with tremendous rapidity, sometimes over a hundred vertical feet an hour; but forty feet is said by some to be the highest rate consistent with good filtration. In this system alum is generally added to the water as a coagulent. Its effect in very small amount is quite remarkable — say a grain to a gallon, or even less — in retaining the solid matters of the water in the sand of the filter. The alum is decomposed by the carbonates in the water, and hydrate of alumina is precipitated. This is a gelatinous and slimy substance and immediately surrounds the algæ, clay, and anything else that may be suspended in the water, and the sand retains this coagulated mass. Alumina has also the effect of taking the color out of water, so that clear, colorless water may be obtained by this process from swampy waters full of growing algæ, with almost incredible rapidity.

These filters are in very general use in paper mills and other industrial works where a clear, colorless water is needed, and where a colored turbid river water is the only natural supply available. They have also been introduced into some cities of considerable size, as, for instance, Long Branch, Chattanooga, and Atlantic, and they are said to give water that is satisfactory to those who use it. The objection to the system is the use of alum. If all the alum used were decomposed in the few seconds that it takes the water to pass through the filter, so that no undecomposed alum passed into the filtered water, there might be no objection to its use; but this is not always the case. The amount of alum used is ordinarily small, and it is claimed that if it even all went into the filtered water it would not injure it for drinking. This may be so, but the prejudice that exists against drinking-water which has been treated with "chemicals" is so strong that it is not likely that any system using a coagulent in a soluble form will find general acceptance. Under some conditions, when the water has high color with much suspended matter, the alum has to be increased largely to give good results. I have known as high as seventeen grains to the gallon to be used with a very bad, swampy water.

In this connection should be mentioned the spongy iron filter of Bischof, which gives most excellent results both in taking out suspended matters from the water, including the bacteria, and also decreases the hardness of the water. This filter has been used on the small scale in houses, and also on the large scale in Antwerp to decolorize and otherwise purify the water of that city. The filter is composed of finely divided metallic iron made by reducing iron ore by means of carbon at a temperature below fusion. Its action was not understood for a long time, and the mystery that surrounded it was an additional recommendation for it. The *rationale* of its working seems to be this, namely, that the iron being in a very finely divided state is dissolved to a slight extent by the combined action of the oxygen and carbonic acid in the water, and the ferreous carbonate thus produced is further oxidized, forming hydrate of iron, and then this acts as a coagulent just as the alumina hydrate does. The system was said to be too expensive on a large scale, and it has now been replaced at Antwerp by the Anderson process, in which the dark water is made to pass through a long revolving iron cylinder in which there is a large quantity of fragments of cast-iron. These fragments of iron in their friction one on the other are abraded, minute particles are broken off which are dissolved in the way above described. The water coming from the revolving cylinder is exposed to the air, the iron oxidizes and precipitates, combines with the coloring matter in the water, encloses the solid particles, and is then filtered out through sand. The process is said to work satisfactorily and give clear colorless water. There is no objection to this use of iron as a coagulent, provided that it is all oxidized and precipitated, and none is carried in solution into the filtered water; but this takes time.

Both alum and iron salts have a tendency to sterilize water. Their action may be both direct by killing the bacteria, and indirect by removing them with the precipitated alumina or iron hydrate. If a drop of a solution of alum, or of iron chloride, be added to a gallon of turbid water, it will become perfectly clear in the course of a few hours, the alumina, or iron hydrate, which is formed in the water, settling to the bottom and carrying all the suspended matters with them. It has been proposed to clarify Mississippi water by adding a very small quantity of an iron solution to the water in the settling basins.

I have laid some weight on the desirability of following nature's processes in the purification of impure waters. Neither the American system with its mighty rush of waters, nor the European system with its calm, steady, and deliberate flow, finds any analogy in nature. In the rapid-working mechanical filters a coagulent is used to grasp and hold the suspended matter; in the continuously working filter-beds the bacteria are put to a novel use in retaining the solid matter on the sticky surface of the sand.

Nature uses these methods also; she removes color by means of clay in the soil and intercepts mechanically in the bacteria-laden soil all the solid matter in the water; but she goes farther than this, and, giving the bacteria full play, breaks up the organic compounds and leaves no trace of their existence behind. To do this time is needed. "The bacteria of nitrification," as Dr. Smart has well said, in referring to the systems of rapid filtration, "cannot be harnessed to the work of artificial filtration."

The rate at which nature works may be expressed in the amount of rain-fall. If we take the rain-fall at fifty inches, and assume that even half of this sinks

into the ground (a very high estimate), we have twenty-five inches yearly on a square foot of surface. The amount of water which goes through the Berlin filters, at a rate of four inches an hour, is more than 1,250 times this amount. If we wish to imitate the process by which nature makes its springs we must pour the water from river or lake which we wish to filter intermittingly on the surface of ground which is favorable for this purpose. The favorable conditions are these: the ground must be sufficiently porous to allow the ready flow of water through it, and it must have such relations to the strata below as will enable us to collect the water at some lower level. It would not profit us much to pour the water on to a gravel bed if we could not find it again after it had been filtered. If the natural conditions for this purpose are not favorable, drains would have to be put in at suitable depths to collect the filtered water. Water purified in this way would in no wise differ from natural spring water, provided that the amount of water applied did not exceed the capacity of the filtering area.

The question of the maintenance of the purity of the water-supplies of large cities which are dependent upon surface waters is daily becoming more urgent in this country as the population becomes more dense on the collecting areas, and the protection of streams against pollution becomes more and more difficult. The radical remedy in such cases is to take water from another and, usually, more distant region, which, it is probable, will never become thickly settled. But in filtration, both intermittent and continuous, when intelligently conducted, we have a substitute which can give as clear, colorless, and, we have good reason also to suppose, safe drinking-water.

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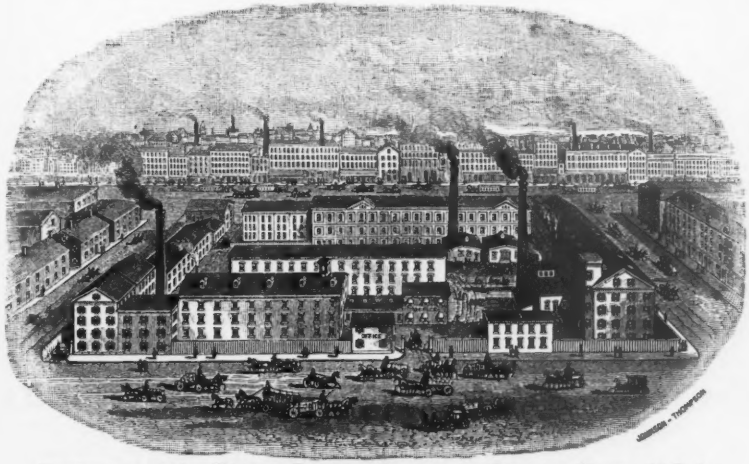

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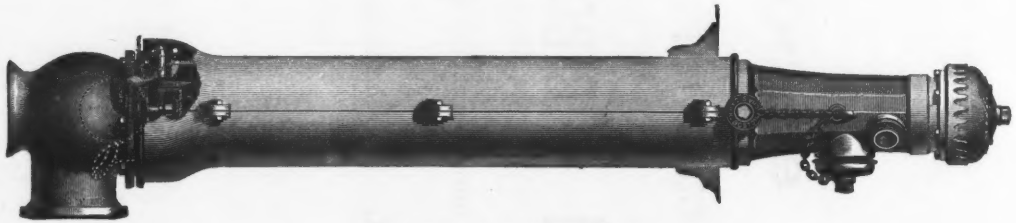

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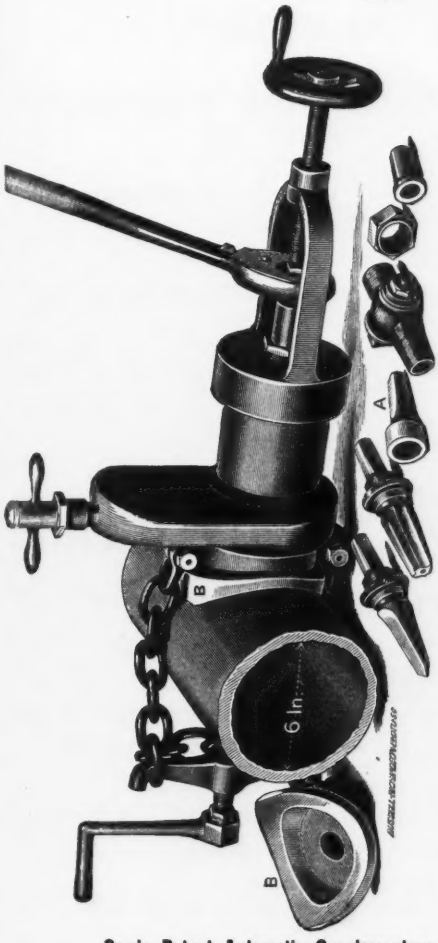

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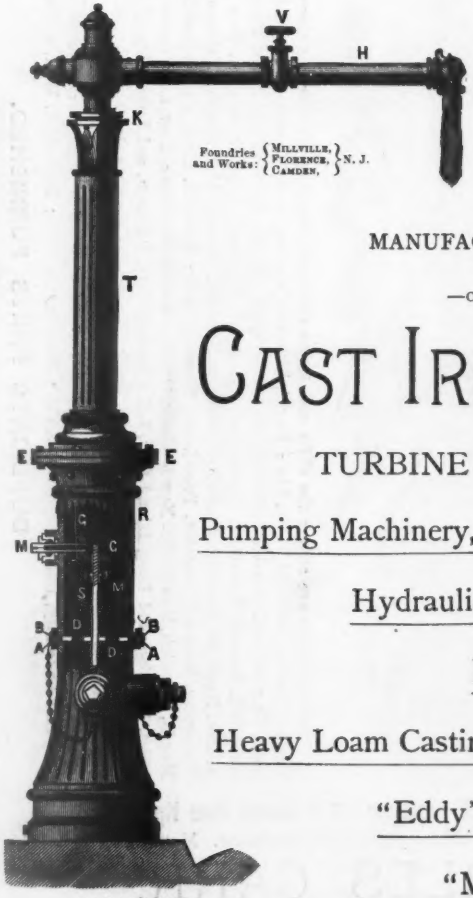

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"We removed one of your 1-inch meters, No. 1765, it having been in service just two years. It had registered 321,040 cubic feet. We tested it and found that it was *very nearly perfect*, and are very much pleased with the showing."

In reply to our request for permission to use the above as a testimonial, we received the following: —

"Have no objection to the publishing of our test of your 1-inch meter, *as they give us less trouble than any others we have in use.*"

ABOUT ONE YEAR AGO A. W. F. Brown, Esq., Water registrar of Fitchburg, Mass., started a durability trial of a ⅝-in Thomson Meter, No. 3250, and at a number of intervals has tested it for accuracy, finding no practical variance up to the last test of Aug. 25, 1890. At that date the meter had delivered 807,789 cubic feet, but it yet registered as follows: —

Diameter of Discharge.	Error in per cent.	
	Plus.	Minus.
3/8	2.0	
1/4	. .	1.0
5/32	0.5	
1/8	2.0	
3/32	0.5	
1/16	4.5	
1/32	11.0	

It may be interesting to note that the above performance of a ⅝-inch meter required approximately 240,000,000 movements of the disk, and to be equalled by a 1-inch meter would necessitate the discharge of nearly 3,400,000 cubic feet.

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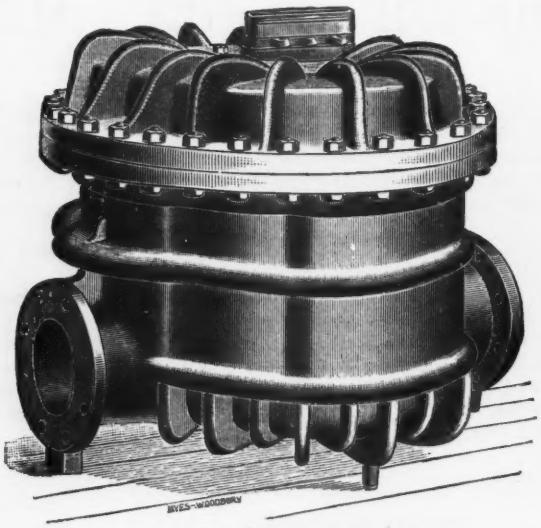

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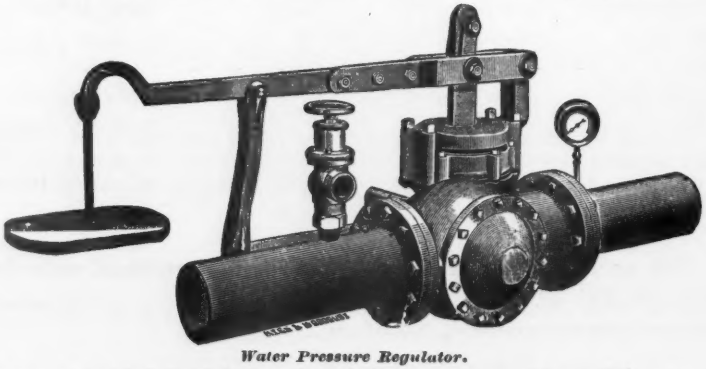

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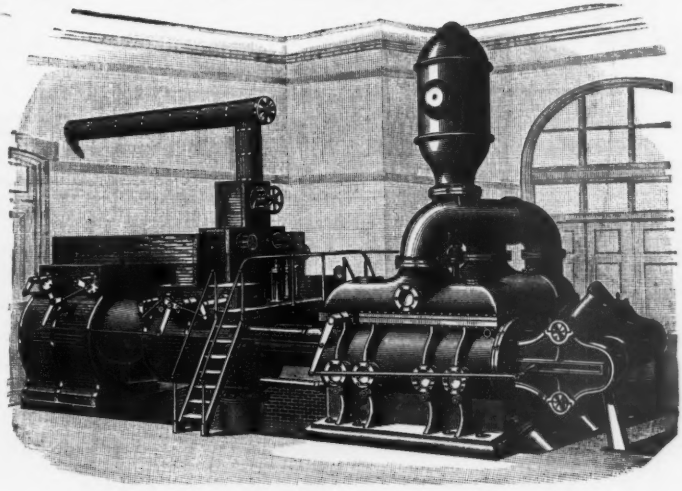

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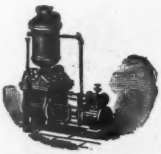

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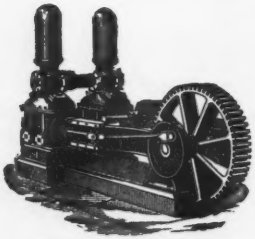

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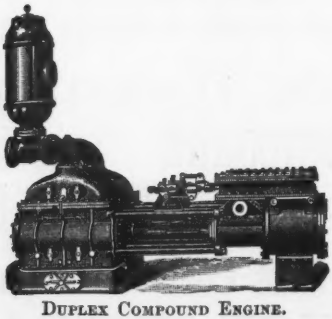

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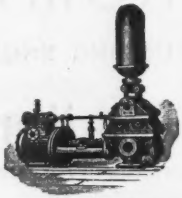

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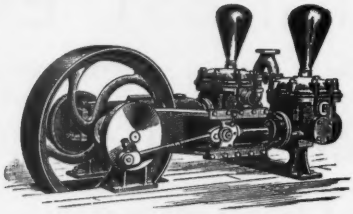

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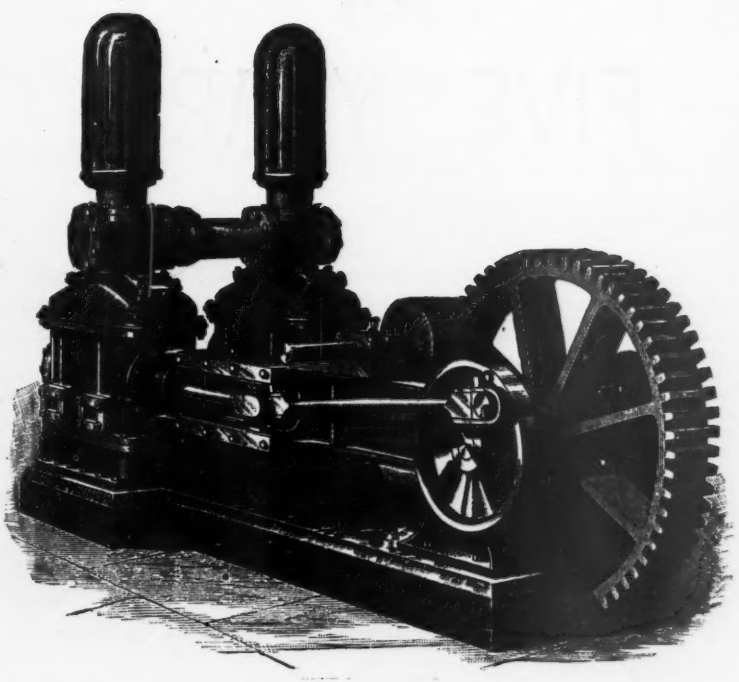

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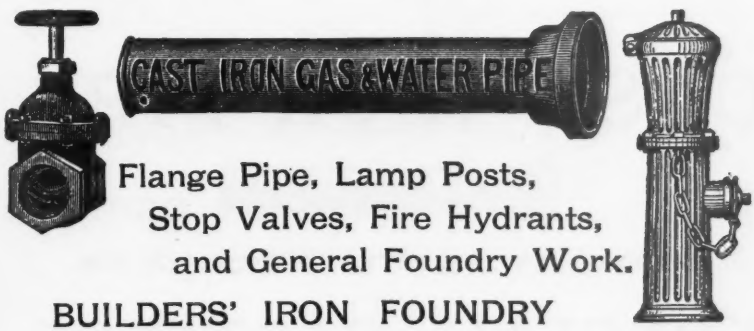

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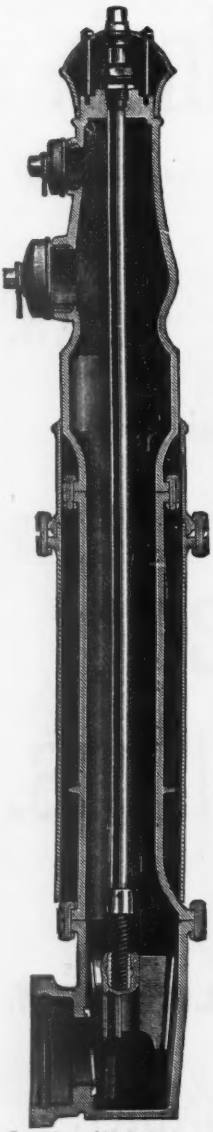

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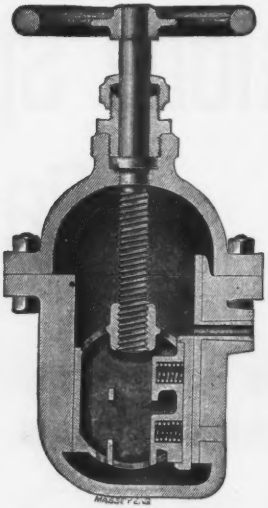

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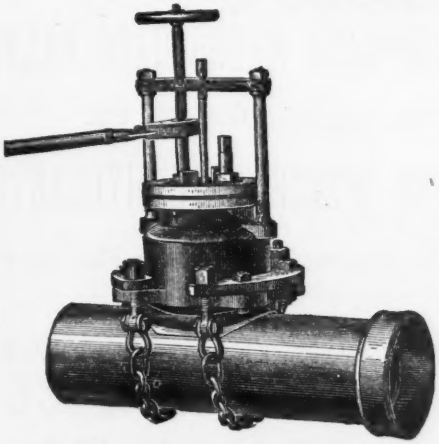

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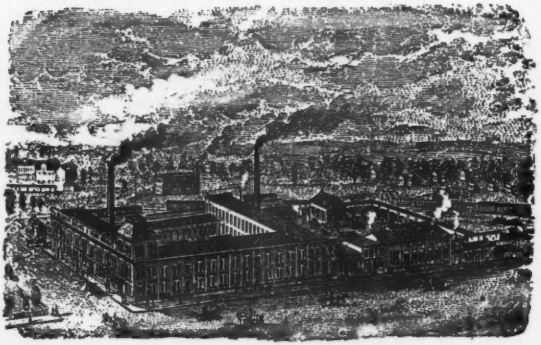

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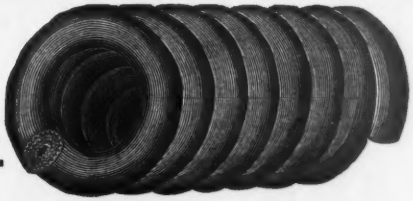

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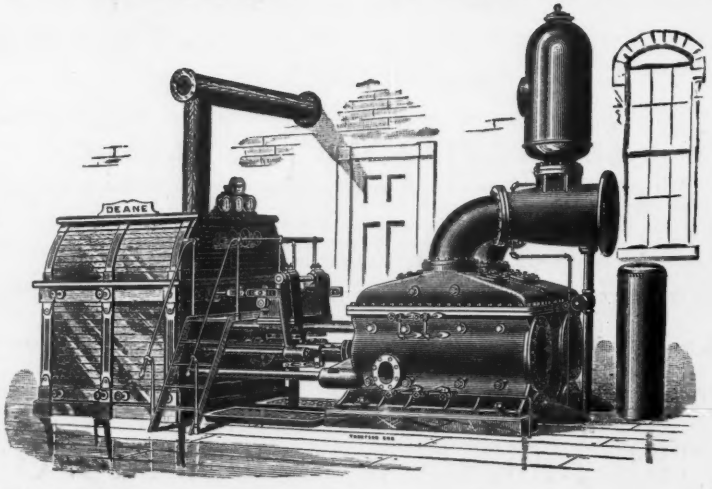

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27

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was organized in Boston, Mass., on June 21st, 1882, with the object of providing its members with means for social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only twenty-seven, its growth has prospered until it now includes the names of more than 375 men. Its membership is divided into two principal classes, viz., Active and Associate. The active membership is further divided into two classes, viz., Resident and Non-resident, — the former comprising those residing within the limits of New England, while the latter class include those residing elsewhere. The initiation fee for the former class is five dollars; for the latter, three dollars. The annual dues for both classes of Active membership is two dollars. The Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is ten dollars, and the annual dues ten dollars. This Association has four regular meetings each year, also a series of informal monthly meetings, during the winter months, at Boston, Mass.

The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with verbatim reports of the discussion. It also contains interesting contributions from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between its members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness. All members of the Association receive the Journal in return for their annual dues; to all others the subscription is two dollars per annum. If upon inspection of the accompanying copy you feel so inclined, we should be glad to receive your subscription.

The Secretary would be pleased to give further information to any one desiring the same. Address,

R. C. P. COGGESHALL,
Secretary New England Water Works Association,
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